

Surgical Treatment

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Introduction

A surgical operation can be defined as “any act performed with instruments or by the hands of a surgeon”.^[1] The goals of surgery are dependent upon the procedure performed, and may involve the diagnostic (i.e. skin biopsy) or therapeutic management of an illness, medical abnormality or injury (i.e. wound closure, gall bladder removal). Healthcare providers should consider all forms of diagnosis and treatment in their thought process and approach to the patient – both operative and non-operative. The logistics of performing a surgery are dependent upon the duration, location, and complexity of the procedure. The patient’s underlying degree of stability or instability and the urgency involved also play a role in the planning of a surgery.

In the context of space flight, the medical resources available to adequately diagnose and surgically treat medical problems must be considered. This includes the equipment/supplies as well as the trained medical personnel required. Microgravity and partial gravity found on other planetary bodies introduce unique additional problems related to lack of convection, gravity, etc. With further increases in crew size and mission duration projected in the near future for the International Space Station (ISS) and exploration-class missions, an increase in the likelihood of occurrence of in-flight medical events that will require surgery is expected.^[2]

Clinical Priority and Clinical Priority Rationale by Design Reference Mission

One of the inherent properties of space flight is a limitation in available mass, power, and volume within the space craft. These limitations mandate prioritization of what medical equipment and consumables are manifested for the flight, and which medical conditions would be addressed. Therefore, clinical priorities have been assigned to describe which medical conditions will be allocated resources for diagnosis and treatment. “Shall” conditions are those for which diagnostic and treatment capability must be provided, due to a high likelihood of their occurrence and severe consequence if the condition were to occur and no treatment was available. “Should” conditions are those for which diagnostic and treatment capability should be provided if mass/power/volume limitations allow.

Conditions were designated as “Not Addressed” if no specific diagnostic and/or treatment capability are expected to be manifested, either due to a very low likelihood of occurrence or other limitations (for example, in medical training, hardware, or consumables) that would preclude treatment. Design Reference Missions (DRMs) are proposed future missions designated by a set of assumptions that encompass parameters such as destination, length of mission, number of crewmembers, number of Extravehicular Activities (EVAs), and anticipated level of care. The clinical priorities for all medical conditions on the Exploration Medical Condition List (EMCL) can be found here (https://humanresearchwiki.jsc.nasa.gov/index.php?title=Category>All_DRM). The EMCL document may be accessed here (https://humanresearchwiki.jsc.nasa.gov/images/6/62/EMCL_RevC_2013.pdf).

| Design Reference Mission | Clinical Priority | Clinical Priority Rationale |
|--|--------------------------|---|
| <p>Lunar sortie mission</p> <p>Assumptions:</p> <ul style="list-style-type: none"> ■ 4 crewmembers (3 males, 1 female) ■ 14 days total ■ 4 EVAs/crewmember ■ <u>Level of Care 3</u> | Not Addressed | <p>Surgical treatment is not addressed in missions where the option of evacuation and abort are a possibility. The likelihood of surgical complications along with the difficulty of providing resources and training for a surgical procedure favor conservative management and ground based treatment after return.</p> |
| <p>Lunar outpost mission</p> <p>Assumptions:</p> <ul style="list-style-type: none"> ■ 4 crewmembers (3 males, 1 female) ■ 180 days total ■ 90 EVAs/crewmember ■ <u>Level of Care 4</u> | Not Addressed | <p>Surgical treatment is not addressed in missions where the option of evacuation and abort are a possibility. The likelihood of surgical complications along with the difficulty of providing resources and training for a surgical procedure favor conservative management and ground based treatment after return.</p> |
| <p>Near-Earth Asteroid (NEA) mission</p> <p>Assumptions:</p> <ul style="list-style-type: none"> ■ 3 crewmembers (2 males, 1 female) ■ 395 days total ■ 30 EVAs/crewmember ■ <u>Level of Care 5</u> | Shall | <p>Given the remoteness of a NEA mission and the inability to return an ill or injured crewmember in a timely manner, surgical capability may be required for conditions for which medical treatment alone is insufficient. The extent of the envisioned surgical capabilities will be determined at a later date through a dedicated Concept of Operations document utilizing flight surgeon input, but is unlikely to include a terrestrial level of surgical care. Prophylactic surgery may be considered as a means to lower the risk of certain surgical conditions yet needs to be balanced with potential complications that may arise months to years after the surgery such as intra-abdominal adhesions with small bowel obstruction.</p> |

Initial Treatment Steps During Space Flight

A link is provided to a prior version of the International Space Station (ISS) Medical Checklist, which outlines the initial diagnostic and treatment steps recommended during space flight for various conditions which may be encountered onboard the ISS. Further diagnostic and treatment procedures beyond the initial steps outlined in the Medical Checklist are then recommended by the ground-based Flight Surgeon, depending on the clinical scenario. Please note that this version does not represent current diagnostic or treatment capabilities available on the ISS. While more recent versions of this document are not accessible to the general public, the provided version of the checklist can still provide a general sense of how medical conditions are handled in the space flight environment. Medical Checklists will be developed for exploration missions at a later point in time.

Please note this file is over 20 megabytes (MB) in size, and may take a few minutes to fully download.

ISS Medical Checklist (http://www.nasa.gov/centers/johnson/pdf/163533main_ISS_Med_CL.pdf)

Capabilities Needed for Diagnosis

The following is a hypothetical list of capabilities that would be helpful in diagnosis. It does not necessarily represent the current capabilities available onboard current spacecraft or on the ISS, and may include capabilities that are not yet feasible in the space flight environment.

- See individual conditions requiring surgical intervention.
- Appropriate laboratory, and imaging capability

Capabilities Needed for Treatment

The following is a hypothetical list of capabilities that would be helpful in treatment. It does not necessarily represent the current capabilities available onboard current spacecraft or on the ISS, and may include capabilities that are not yet feasible in the space flight environment.

- Surgical suite (proper lighting, sterile field, containment of fluid and gas)
- Surgical instruments (TBD)
- Sterilizer for instruments
- Suction
- Cauterization capability
- Intravenous (IV) start and administration kit
- Intravascular volume replacement (such as IV fluids)
- IV pump or pressure infuser
- Sterile gloves
- Sterile gown
- Head, face, and shoe covers
- Sterile drapes

- Anesthesia
- Hemostasis
- Blood products
- Surgical catalog
- Post-surgical monitoring
- Post-surgical nursing care
- Pharmacy (Analgesics (narcotic, oral and injectable), Antibiotics, etc.)
- Rehabilitation capability
- Clinical laboratory
- Imaging devices

Associated Gap Reports

The NASA Human Research Program (HRP) identifies gaps in knowledge about the health risks associated with human space travel and the ability to mitigate such risks. The overall objective is to identify gaps critical to human space missions and close them through research and development. The gap reports that are applicable to this medical condition are listed below. A link to all of the HRP gaps can be found here (<http://humanresearchroadmap.nasa.gov/Gaps/>).

- 1.01 - We do not know which emerging technologies are suitable for preflight medical screening for exploration missions.
- 2.01 - We do not know the quantified health and mission outcomes due to medical events during exploration missions.
- 2.02 - We do not know how the inclusion of a physician crew medical officer quantitatively impacts clinical outcomes during exploration missions.
- 3.01 - We do not know the optimal training methods for in-flight medical conditions identified on the Exploration Medical Condition List taking into account the crew medical officer's clinical background. (Closed)
- 3.03 - We do not know which emerging technologies are suitable for in-flight screening, diagnosis, and treatment during exploration missions.
- 4.01 - We do not have the capability to provide a guided medical procedure system that integrates with the medical system during exploration missions.
- 4.02 - We do not have the capability to provide non-invasive medical imaging during exploration missions.
- 4.04 - We do not have the capability to deliver supplemental oxygen to crew members while minimizing local and cabin oxygen build-up during exploration missions.
- 4.05 - We do not have the capability to measure laboratory analytes in a minimally invasive manner during exploration missions.
- 4.07 - Limited wound care capability to improve healing following wound closure (Closed)
- 4.09 - We do not have the capability to provide medical suction and fluid containment during exploration missions.
- 4.12 - We do not have the capability to generate and utilize sterile intravenous fluid from potable water during exploration missions.
- 4.14 - We do not have the capability to track medical inventory in a manner that integrates securely with the medical system during exploration missions.
- 4.15 - Lack of medication usage tracking system that includes automatic time stamping and crew identification
- 4.17 - We do not have the capability to package medications to preserve stability and shelf-life during exploration missions.
- 4.19 - We do not have the capability to monitor physiological parameters in a minimally invasive manner during exploration missions.
- 4.24 - Lack of knowledge regarding the treatment of conditions on the Space Medicine Exploration Medical Condition List in remote, resource poor environments (Closed)

5.01 - We do not have the capability to comprehensively manage medical data during exploration missions.

Other Pertinent Documents

List of Acronyms

| | |
|----------|---|
| D | |
| DRM | Design Reference Mission |
| E | |
| EMCL | Exploration Medical Condition List |
| EVA | Extravehicular Activity |
| H | |
| HRP | Human Research Program |
| I | |
| ISS | International Space Station |
| IV | Intravenous |
| M | |
| MB | Megabyte |
| N | |
| NASA | National Aeronautics and Space Administration |
| NEA | Near Earth Asteroid |
| T | |
| TBD | To Be Determined |

References

1. Krummel TM. What is surgery? Semin.Pediatr.Surg. 15.4 (2006): 237-41.
2. Campbell MR and Billica RD. Surgical Capabilities. Principles of Clinical Medicine for Space Flight. Ed. MR Barratt and SL Pool. New York: Springer, 2008. 123-37.

Last Update

This topic was last updated on 8/13/2014 (Version 2).

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